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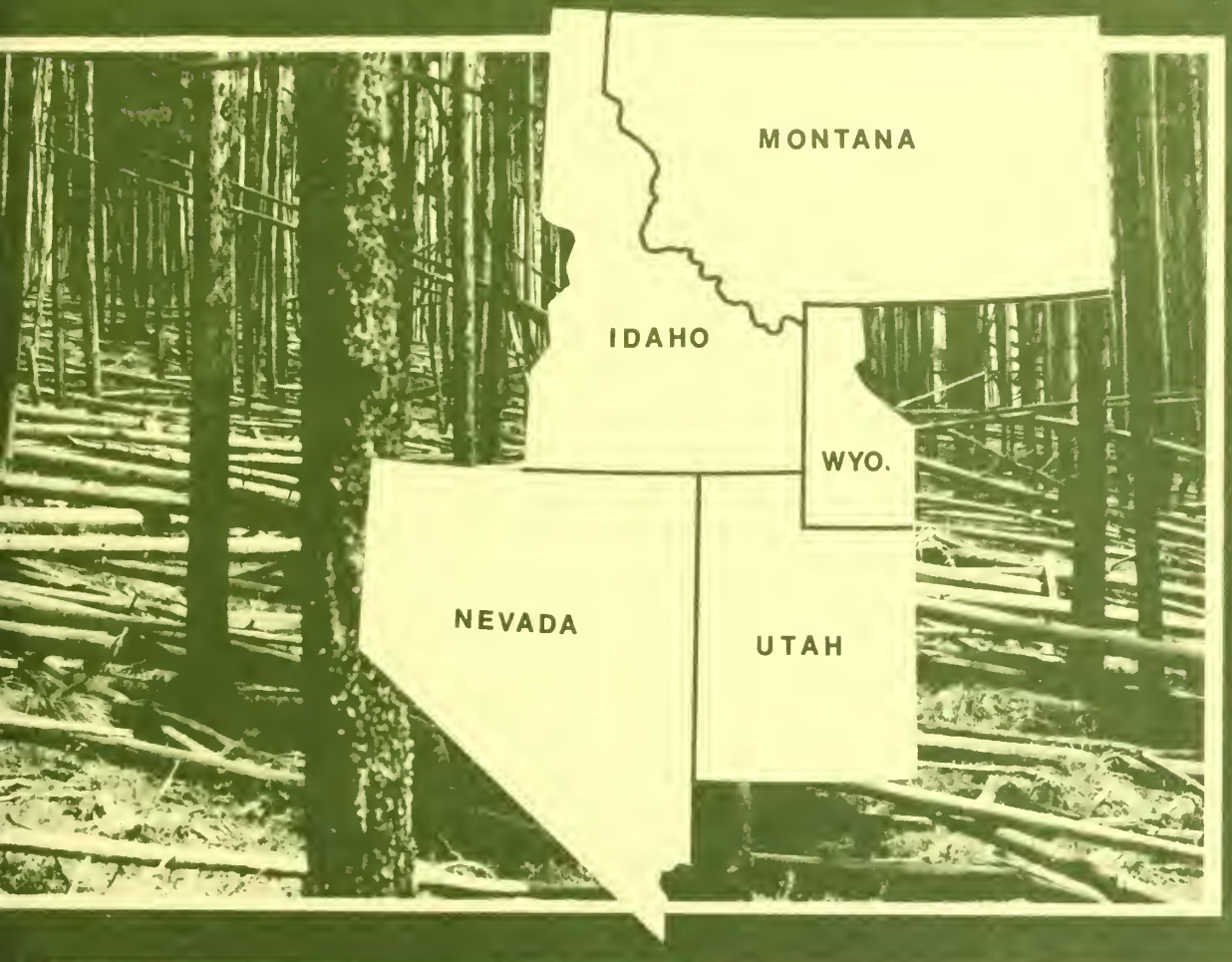

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RESEARCH SUMMARY

The volume of forest residues in six principal forest types in Montana, Idaho, and Wyoming was estimated from samples in mature stands and research study logging units. Forest residues include standing and down dead material as well as small and defective green material that is at least 3 inches (7.6 cm) diameter but will not meet current merchantability standards for saw logs. The amount and condition of forest residues varies widely from stand to stand. The amount remaining after harvest also depends on utilization standards and harvesting techniques.

Residue volumes ranged from 1,300 ft^3/acre (90 m^3/ha) in dry-site Douglas-fir to 3,700 ft^3/acre (260 m^3/ha) in grand fir. One-third of the residues would be suited for roundwood products such as posts, poles, or house logs. In total, about 450 million ft^3 (13 million m^3) of residues are generated through logging each year in these three States. There is an additional 10 to 25 tons per acre (22 to 56 t/ha) of tree crowns and small woody material on the ground. The on-ground material can be important to the forest as nutrients, wildlife habitat, microsite influence, or as a fire hazard following logging.

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INTRODUCTION

Recent years have seen growing interest in forest residues--the woody material that is left after harvesting. This interest stems from two basic concerns: residues as a source of additional wood fiber at a time of dwindling timber supplies and the role of residues in the forest environment. On the one hand, dead trees may provide habitat for birds and small animals, and down material may provide protection against soil erosion and in the process of decay provide essential nutrients to the site. On the other hand, the public dislikes unsightly accumulations of logging debris, and dead and down material can be a fire hazard or impede movement of wildlife.

The amount and characteristics of residue material vary widely, depending on stand conditions. In addition to the large live trees, a typical mature stand holds small suppressed or defective stems, standing dead trees of various sizes, and an accumulation of down material. If the stand is decadent, the amount of dead and rotten material may be high. Insect or disease outbreaks may kill a large proportion of the stand, leaving large volumes of standing and down dead material.

This report summarizes the volume and characteristics of residues in mature stands of several principal forest types in the Northern Rocky Mountains. The estimates of residue volumes are based on data from various research study sites plus data from forest inventories.

The data base used in this report is limited primarily to old-growth stands in major forest types. These were of first priority in our studies simply because this is where most of the harvest and logging residue problems will occur during the next few years.

The purpose of this report is to serve general information needs for broad-scale resource assessment and planning. Any given forest or stand may vary considerably from the typical or average stand conditions and the manager may require specific in-place studies to meet his needs. The available handbooks, computation facilities, and references useful in assessing specific residue situations are cited.

DATA SOURCES AND METHODS

The data used in this summary have been gathered from three principal sources. USDA Forest Service statistics were used for forest acreage and volume.[1] National forest timber management data were used to describe in more detail the forest conditions involved in the dead timber resource.[2] Research and administrative studies in specific areas provided detailed description of dead timber and utilization characteristics.

Although there is wide variation in residues between individual stands, these data should be reasonably representative for mature and overmature sawtimber stands of various forest types.

On the residue study sites, volumes of standing trees were determined using conventional forest survey methods: variable plot tally for larger trees, fixed plots for smaller trees. Volume of down material was estimated using the planar intercept techniques (Brown 1974a). In addition, standing dead and down material was evaluated for piece size, product potential, and condition by field crews.

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[1]From data prepared for "Forest Statistics of the United States, 1977," USDA Forest Service 1979, by the Resources Evaluation Research Work Unit, Intermountain Forest and Range Experiment Station, Ogden, Utah.

[2]Timber management plans and ADP summary statistics printouts on file at USDA Forest Service, Region 1, Federal Building, Missoula, Mont.

These characteristics were then applied to forest types to derive estimates of total residues. Forest types are the principal strata used for describing residues because species, amounts, and conditions of wood are most closely tied to forest type, and managers still basically plan their harvests on the basis of forest types. Physiographic conditions, habitat types, and other factors may, of course, influence the way in which the timber is harvested and consequently may affect residue removal. In addition, logging methods and utilization standards vary between different locations and may in part determine residues left from harvesting.

The area and volume of wood per acre for the forest types included in this study are shown in table 1. The volume per acre from the residue studies data is greater than National Forest data. This is because we have defined as residues any material 3 inches in diameter or larger, other than the merchantable portions normally removed in harvesting. This includes small stems, tops of merchantable trees, cull trees, dead trees, and down material. In contrast most forest statistics include only the merchantable portions of live trees, and in some cases recently dead trees. Data sources are listed in the appendix.

Table 1.--*Area and total volume per acre, sawtimber stands, selected forest types, Northern Rocky Mountains*[1]

Forest type	Area		Volume	
	All sawtimber[2]	Mature sawtimber[3]	National Forest data[4]	Residue studies data[5]
	M acres(M ha)	*M acres(M ha)*	*Ft^3/acre(m^3/ha)*	*Ft^3/acre(m^3/ha)*
Douglas-fir				
Moist site	3,474.3(1 406)	2,432.0(984)	3,535(247)	4,686(328)
Dry site	3,945.9(1 597)	2,762.1(1 118)	2,344(164)	2,955(207)
Lodgepole pine	3,189.6(1 291)	2,551.7(1 033)	3,223(225)	5,325(373)
Larch	1,070.5(433)	728.8(295)	4,475(313)	6,823(477)
Grand fir and associated species	1,378.1(558)	1,102.5(446)	4,364(305)	7,991(559)
Alpine fir	1,784.1(722)	1,784.1(722)	3,717(260)	{4,158(291)}
Engelmann spruce	1,228.8(497)	1,228.8(497)	3,558(249)	

[1]Ponderosa pine, white pine, and cedar-hemlock types were not included in residue, but acreage data for sawtimber is available in "Forest Statistics" (see footnote 1 in text, page 1).

[2]From "Forest Statistics" data, all ownerships (see footnote 1 in text, page 1).

[3]Estimated for all ownerships by using proportions from National Forest data.

[4]Compiled from National Forest data; includes only wood meeting current size and merchantability criteria (appendix).

[5]Obtained from residue studies at selected points; includes all woody material 3-inch (7.62 cm) diameter and larger (appendix).

Availability of residues is a significant factor in evaluating their use potential. In the Northern Rocky Mountains availability of timber for harvesting depends on the land-use plans, and for much of the area this, in turn, is contingent on environmental protection, endangered species habitats, and intensity of management provided for in resource planning. Much of the timber management and land use planning is not yet complete. In this report we have assumed that residues will be recovered primarily in conjunction with timber harvesting schedules.

RESIDUE VOLUMES IN THE MAJOR FOREST TYPES

The area of sawtimber for the principal forest types included in this study totals 16 million acres. Of this, about 13 million acres are mature sawtimber, mostly 100 years or more in age. A portion of the mature sawtimber is actually overmature or decadent, with high volumes of dead and defective material. Total volume of wood in residue study samples ranged from just under 3,000 ft^3/acre (210 m^3/ha) in dry-site Douglas-fir to nearly 8,000 ft^3/acre (560 m^3/ha) in moist, overmature grand fir stands.

The volume components are shown in table 2. The wide range in total volume and in the proportions of each component affects the potential for utilization. The green-merchantable category mainly includes saw log and veneer log portions of live stems, but also may include recently dead trees. The definition of merchantable and the top diameter limit varies somewhat among species. Cull portions vary considerably from stand to stand, even within species. Cull may be bucked out and left in the woods or brought in with the log, depending on the size and kind of material.

Table 2.--*Volume of wood by component in mature stands, residue study areas*[1]

Component	Forest type					
	Lodgepole pine	Western larch	Douglas-fir		Grand fir	Spruce-alpine fir[2]
			Moist site	Dry site		
	Volume, ft^3/acre					
Green trees						
Merchantable log	2,225	3,401	2,546	1,658	4,283	2,000
Cull	119	222	334	52	564	391
Top	457	132	105	75	208	300
Small stems	244	663	527	300	156	380
Subtotal	3,045	4,418	3,512	2,085	5,211	3,071
Standing dead						
No defect	436	86	180	0	24	153
Sound defect[3]	291	30	49			
Solid rot	139	493	36	22	256	68
Crumbly rot	0	302	55	0		
Subtotal	866	911	320	100	280	221
Down						
No defect	356	108	267	43	281	455
Sound defect[3]	310	66	52	19	7	43
Solid rot[4]	213	124	137	181	309	106
Crumbly rot[4]	233	1,196	398	527	1,903	262
Subtotal	1,112	1,494	854	770	2,500	866
Total, ft^3/acre	5,023	6,823	4,686	2,955	7,991	4,158
(m^3/ha)	(351)	(478)	(328)	(207)	(559)	(291)

[1]Top volumes and stem volumes for small trees compiled from Faurot (1977).

[2]Breakdown of total into components estimated.

[3]Sound defect includes crook, sweep, fork, splits, and drying checks that prevent use for solid wood products but not for fiber use.

[4]Solid rot includes pieces with rot but that can be handled in logging. Crumbly rot is material that will not hold together in logging.

The volume in tops of merchantable trees (the portion between the merchantable top and a 3-inch diameter) and of small stems in the sawtimber stands also vary. In some trees, such as large, mature Douglas-fir, the top bole may taper very quickly, while alpine fir usually has a long, slim "spear-like" top bole. Similarly, there may be very few small understory stems in some dense mature sawtimber stands; or small stems may be a sizeable part of the volume in mixed-age stands where sawtimber overstory is patchy, such as the Douglas-fir stand in figure 1.

Figure 1.--Mixed-age Douglas-fir and larch, with many understory trees that contribute to residue volume.

DEAD MATERIAL

Dead material, either standing or down, comprises the largest residue component of mature stands. Dead trees accounted for one-fourth to more than one-third of the total volume of stands sampled. Condition of dead material varies among forest types, as shown in figure 2. Sound dead material (with no defect or with sound defect) ranges from only 11 percent of standing and down dead material in grand fir to 70 percent in lodgepole pine.

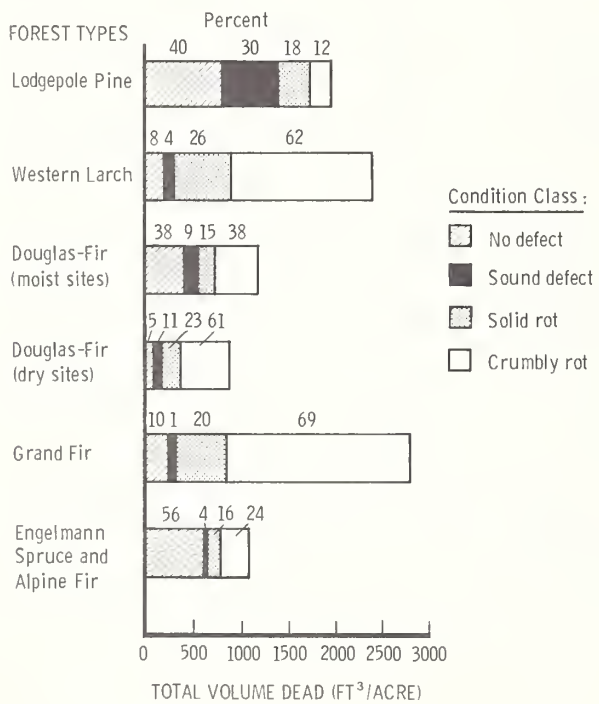

Figure 2.--Volume and percentage of dead material by condition class, principal forest types.

The utilization potential of the dead material also varies considerably. Dead stems are more susceptible to breakage from natural factors such as wind and during falling and yarding operations. Product potential of dead material is affected by whether the material is standing or down and the rapidity of decay on the site. The condition and use potential for dead material in each forest type is discussed below.

Lodgepole Pine

Lodgepole pine is one of the largest forest types in the Northern Rockies and has been utilized less than other types. Much of the lodgepole is overmature or insect-killed, with large numbers of dead trees in many stands. Lodgepole grows at high elevations on cool, dry sites, and consequently the dead material does not decay rapidly (fig. 3).

Figure 3.--Overmature lodgepole pine. Half the volume is dead but could be used for house logs, posts, or fiber products.

Dead trees, both standing and down, comprise over one-third of the volume in mature and overmature lodgepole pine stands. Throughout much of the Northern Rockies, persistent dwarf mistletoe infection and periodic bark beetle epidemics have led to large accumulations of dead material. In northern Idaho and northwestern Montana, lodgepole has often succeeded other species following fires and some of the dead volume is remnant of an earlier stand of larch, Douglas-fir, or other species.

Forty percent of the dead material was merchantable, with no defect that would prevent its use for roundwood products. Thirty percent had sound defect such as deep checks, breaks, or crooks that would prevent use for roundwood, but not for chips or other fiber products. Another 18 percent contained rot, but was solid enough to be handled in logging, and would be suited for fuel and possibly some fiber products.

In virtually all areas studied the percentage of rot was low in standing trees. Condition of down dead material appeared to be related to how long the material had been down, how far off the ground it rested, and general climatic conditions.

Utilization potential in dead timber also depends on piece size. Standing dead trees in lodgepole pine are generally whole or with only small lengths of the top broken out. Down timber, however, is frequently broken. On the average, the sound down pieces were long enough (9 feet [2.7 m] or longer) and of large enough diameter (3 inches [7.62 cm] or more) to be utilized in some product (table 3).

Table 3.--*Number of sound down pieces by diameter and length class, selected forest types*

Length and diameter[1]	Forest type			
	Lodgepole pine	Western larch	Douglas-fir moist site	Douglas-fir dry site
	Pieces per acre (per hectare)			
1 to 8 feet long				
3 inches and larger diameter	23 (57)	18 (44)	47 (116)	5 (15)
9 to 18 feet long				
3 to 6 inches diameter	49 (121)	20 (49)	34 (84)	4 (10)
6 inches or larger diameter	9 (22)	4 (10)	11 (27)	2 (5)
19 feet and longer				
3 to 6 inches diameter	28 (69)	13 (32)	28 (69)	4 (10)
6 inches or larger diameter	18 (44)	10 (25)	28 (69)	2 (5)

[1]Equivalent metric classes are:

1 to 8 feet = 0.3 m to 2.4 m
9 to 18 feet = 2.7 m to 5.5 m
19 feet + = 5.8 m and longer

3 inches diameter and larger = 7.62 cm +
3 to 6 inches = 7.62 to 15.24 cm
6 inches or larger = 15.24 cm +.

In several study areas the potential for specific roundwood products was evaluated (table 4). A fairly large number of products could be recovered from lodgepole pine stands--on the average over 350 pieces per acre (865/ha), including 22 house logs and 41 saw logs per acre.

These data on products and size of sound pieces indicate the potential for utilization, but it should be recognized that these figures vary widely, depending on stand size and age, condition, and stocking. For example, on the Targhee National Forest, where lodgepole grows fairly large and where it has not been dead very long, there are 2 to 3 times as many sound pieces as in other areas where overstocking has occurred and trees have been dead a long time. A study made on the Targhee found an average of 3 to 4 standing dead trees per acre suited for transmission poles, in addition to the products listed above (Tegethoff and others 1977).

Western Larch and Douglas-fir, Moist Sites

The Northern Rockies hold extensive fir-larch forests that provide much of the timber harvest. Larch is often present in the moist-site Douglas-fir stands of this study. Fir-larch is common in Idaho north of the Salmon River and Montana north and west of Missoula. In the larch and fir stands in our residue studies, larch average slightly more green wood volume than the Douglas-fir stands and about twice as much dead volume.

Table 4.--*Number of potential products from standing and down dead pieces, selected forest types*

Product and type piece[1]	Lodgepole pine	Western larch	Douglas-fir moist sites
	Pieces per acre (per hectare)		
House logs			
Standing	9 (22)	1 (2)	2 (5)
Down	13 (32)		
Saw logs			
Standing	21 (52)	3 (7)	7 (17)
Down	20 (49)		
Corral rails			
Standing	43 (106)	3 (7)	5 (12)
Down	46 (114)		
Posts			
Standing	36 (89)	1 (2)	2 (5)
Down	44 (109)		
Pulp bolts			
Standing	51 (126)	30 (74)	57 (141)
Down	75 (185)		

[1]Minimum specifications were:

House logs - 9 inches (23 cm) dia., 8 feet (2.4 m) long, no crook, sweep, rot, or checks that preclude use as house log.
Saw logs - 6 inches (15 cm) dia., 8 feet (2.4 m) long, one-third sound.
Corral rails - 3 inches (7.6 cm) dia., 10 feet (3 m) long, reasonably straight, no rot or major checks.
Posts - 3 inches (7.62 cm) dia., 7 feet (2.1 m) long, no crook, rot or major checks.
Pulp bolts - 3 inches (7.62 cm) dia., 8 feet (2.4 m) long, sound enough to hold together in yarding.

In both forest types, more than half the dead material is rotten and only about one-third is defect free, probably because of more rapid decay than in lodgepole pine stands. In standing dead trees, more than one-third the volume is rotten.

Although rot was common, some sound pieces could potentially be recovered. Most of the species in larch and fir stands are not normally used for posts, poles, and other products. Because species utilization is continually changing and to accurately assess the residue, product evaluations were made for all material, regardless of species.

Unlike lodgepole, with its potential for many high-value products, most of the dead material in larch and fir was suited only for pulp. This was primarily because in fir and larch stands the smaller suppressed understory trees were often of poor form.

The condition of wood and potential for utilization varied considerably in mature fir and larch stands. Often three or four age classes were present, with the oldest usually deteriorated and the youngest fairly vigorous. For example, in larch stands classed as high risk sawtimber there was three times the volume of rotten dead and cull material as there was in the low-risk stands.

Douglas-fir , Dry Site

A portion of the Douglas-fir forest throughout Wyoming, southwestern and eastern Montana, and southern Idaho was designated as dry site Douglas-fir in this study. Generally, wood volumes were lower, there was less understory vegetation, and the residues were somewhat different than in Douglas-fir moist sites.

The volume of material in dry-site fir was about two-thirds of the moist-site. Proportionately, there was much less standing dead on the dry site, which probably reflects lighter stocking of understory trees than on moister sites. The volume of down dead material was proportionately greater than on moist sites. On drier sites the down material remains intact longer whereas in moist sites it deteriorates and becomes part of the litter and duff layer more rapidly. Down material on these sites has little product potential except for fiber or fuel.

Grand Fir

The data for the grand fir type were taken primarily in the Horse Creek study area on the Nezperce National Forest in Idaho, with some additional data from samples from the Flathead and Kootenai Forests in Montana. The samples were mostly in decadent, high-risk stands and probably had higher volumes of dead and cull than the average sawtimber stand of this type.

A high proportion of the total cubic volume was defective--cull and rotten dead accounted for more than one-third of the volume (fig. 2). The Horse Creek study area had as high as 4,000 ft^3/acre (280 m^3/ha) of crumbly rot. In other areas, stands were less deteriorated and volume of rot was usually about 1,000 ft^3/acre (70 m^3/ha). Because of the high incidence of rot, the data on sound pieces per acre of dead material were not meaningful. We estimated about 10 sound pieces per acre over 8 feet (2.4 m) long could be cut from the dead material in these stands.

Alpine Fir and Engelmann Spruce

Total area in alpine fir and Englemann spruce is not large, but these forest types are common at higher elevations and in wet areas throughout the Northern Rockies. Because data were limited, and because alpine fir and Engelmann spruce are usually mixed, data were combined for these types. Volume of dead material averaged 1,100 ft^3/acre (77 m^3/ha), about half of which was sound (table 2).

The alpine fir-Engelmann spruce sites receive high precipitation; however, much of the year temperatures at these high elevations are too low for optimum decay. About 25 posts and corral rails plus a few house logs or saw logs could be recovered from the dead material on each acre. Residues of these species are seldom utilized for roundwood products.

GREEN MATERIAL

Fifteen to twenty percent of the total material more than 3 inches in diameter is green "residues," that is, material that does not meet conventional product specifications. Green residue includes tops of merchantable trees and small stems that do not meet minimum d.b.h. requirements. The proportion of different kinds of green residues is tabulated below, based on data from table 2:

	Lodgepole pine	Western larch	Douglas-fir, moist	Douglas-fir, dry	Grand fir	Engelmann spruce/ alpine fir
	Percent of total cubic foot volume					
Green residues						
Cull	2	3	7	2	7	9
Tops	9	2	2	3	3	7
Small stems	5	10	11	10	2	9
Merchantable green	44	50	54	56	54	48
Dead	40	35	26	39	34	27
Total	100	100	100	100	100	100

The amount of green material that actually remains following harvest could be more or less than these estimates, depending on the utilization level specified in the sale, the kind of harvest system used, and on the actual stand conditions. One study of logging residues in Idaho and Montana indicated that in addition to green residue material not meeting saw log specifications (cull and small stems), another 14 percent of the net green volume in the form of broken pieces or merchantable logs missed in yarding also remained (Wilson and others 1970). However, this study was based on sampling areas harvested in the mid-1960's. Since that time, logging practices and utilization specifications have changed. We estimate that currently about 15 percent of the total preharvest volume is left as green residues, and very little of this is merchantable material. This estimate is based on residue studies with several different logging and utilization specifications (Benson and Johnston 1976).

Table 5 shows residue volumes on harvested sites included in our residue research studies. With "conventional"[3] logging, green residues ranged from 7 percent to 29 percent of the total preharvest volume, and varied considerably among sites. With intermediate utilization and close utilization, green residues are only a small part of the volume remaining.

Fine Fuels

Small material less than 3 inches (7.62 cm) in diameter is of crucial concern in managing residues. A high proportion of the nutrient content of trees is in the needles, fine twigs, and bark, and the land manager must decide how much of this material should be left on the site.

If prescribed burning is to follow harvesting, the type, amount, arrangement, and moisture content of fine fuels help determine the success of the burn. Crown weights for several forest types were estimated in accordance with procedures developed by Brown (1977). Crown weights are related to size and form of the tree, and therefore are highly variable. For the study areas, crown weights averaged:

Crown components and size	Larch and Douglas-fir	Lodgepole	Grand fir
	Tons/acre (t/ha)		
0-1/4 inch diameter	5.36 (12.0)	2.25 (5.0)	3.36 (7.5)
1/4 - 1 inch diameter	7.65 (17.1)	3.10 (6.9)	6.79 (15.2)
1 - 3 inch diameter	3.06 (6.9)	1.86 (4.2)	4.99 (11.2)
Total, woody	16.07 (36.0)	7.21 (16.1)	15.14 (33.9)
Foliage	9.44 (21.1)	2.97 (6.6)	8.31 (18.6)

[3]Exact utilization specifications and detailed data on residues are on file at the Forestry Sciences Laboratory, Missoula, Mont. Generally, "conventional" means removing any logs to a minimum 6-inch top diameter, one-third or more sound volume.

Table 5.--*Logging residue volumes following clearcutting, various study sites*

Utilization level, study site and forest type	Total 3-inch + preharvest volume	Postharvest residue volume		Postharvest green as percent of total preharvest
		Dead	Green	
	- - - - - - - - $Ft^3/acre$ - - - - - -			
Conventional utilization[1]				
Lolo (Mont.)	5,575	1,212	1,543	27
Coram (Mont.) DF&L	6,970	2,459	499	7
Lubrecht (Mont.) DF&L	3,047	343	892	29
Teton (Wyo.) LPP	10,164	2,402	1,165	11
Northern Idaho (mixed conifer)	7,947	347	1,794	23
Intermediate utilization[2]				
Coram, 7-inch (DF&L)[1]	7,534	1,873	207	3
Coram, 5-inch (DF&L)[2]	8,137	1,578	129	2
Bitterroot (Mont.) LPP	4,973	1,400	42	1
Close utilization[3]				
Coram (DF&L)	6,297	1,434	44	1
Lubrecht (DF)	3,082	362	0	0
Teton (LPP)	9,673	700	131	1

[1]Generally, 7-inch or 9-inch d.b.h. green trees to a 6-inch small-end log diameter.

[2]Included smaller diameter trees (5-inch d.b.h.) than conventional utilization, and required removal of sound dead material.

[3]Required removal of virtually all material that could be handled by yarding machines (pieces down to 3-inch diameter by 8 ft long, and whole trees down to 1-inch d.b.h. at Coram and Lubrecht).

Fine material was measured on sites logged to conventional standards and close utilization standards. In one study, fuel depth with close utilization was less than half that of conventional utilization, and fuel weight was only about 20 percent of that on the conventional utilization (Brown 1974b). This reduced both rate of fire spread and fire intensity. Similar results (unpublished) were noted in other study areas.

ESTIMATING RESIDUES AND UTILIZATION POTENTIAL

Estimates of residue volumes and utilization potential are based on averages of a large number of samples of forest stands and cutting units. In the discussion we emphasized there was wide variation in these averages; for example, some individual stands have virtually no sound down material, while other stands in the same type may have several thousand cubic feet per acre of this material.

An attempt was made to relate various residue volumes with stand conditions to see if there were some basis for refining estimates of residues within the broad strata of mature stands by forest type. In general, no close relationships among various residue components and stand conditions were found. As might be expected, the total volume of wood was related to factors such as site index, stand age, moister aspects and habitat types, etc. But within this total volume, the percent of dead material was not closely related to basic site conditions.

This can be attributed to the development of the stand over time. When stands are young and vigorous their growth, development, and mortality losses can be predicted with some certainty. However, mature stands are subject to a number of interacting factors such as fire, insects, disease, and storms that determine residue conditions, and these may occur at irregular intervals.

As a result, even within a narrow forest type such as high-risk, old-growth Douglas-fir, some stands are virtually intact with very little cull or down material, while others have had heavy mortality years ago, resulting in a high proportion of the stand being down and rotten.

Techniques are available for accurately predicting residue and fuel generated in harvesting specific stands (Brown 1974a, 1977). These predictions are based on formulas applied to stand data on species, d.b.h., number of stems, and so on.

RESIDUES CREATED ANNUALLY FROM CURRENT HARVEST

The total roundwood harvest in Montana, Idaho, and Wyoming in 1976 was 3.2 billion board feet. We estimate that residue material other than green merchantable logs totaled about 446 million cubic feet (12.6 million m^3). The volume of material by component for the forest types included in the above residue studies totals about 356 million cubic feet (10.1 million m^3).

Residue component	Million ft^3	Million m^3
Green (cull, tops, and small trees)	123.2	3.5
Dead - sound defect and no defect	88.1	2.5
Dead - solid rot	39.7	1.1
Subtotal	251.0	7.1
Crumbly rot	104.7	3.0
Total residue[1]	355.7	10.1

[1]Lodgepole pine, Douglas-fir, western larch, grand fir, and subalpine fir.

This residue volume is what would be generated if the entire harvest was clearcut. We know that a substantial portion of the harvest came from partial cutting, but our studies indicate the total residue volume generated would not be substantially different under partial harvesting. Therefore, the harvest was converted to an equivalent acres of clearcutting so residue study data based on clearcuts could be applied to derive residue volumes.

In addition, an estimated 110 million cubic feet (3.1 million m^3) more would be generated from species (ponderosa pine, western white pine, western hemlock, western redcedar) not included in residue studies. The details of these estimates are shown in table 6.

Not all this residue volume should be considered as additional material available for utilization. The crumbly rotten material would remain on the site. Some of the cull material would be removed with merchantable material and end up as mill residues. A portion of the sound dead material is considered merchantable under current sales practice. In total, however, there is probably 300 to 350 million cubic feet (8.5 to 9.9 million m^3) of additional material as woods residue.

Table 6.--*Volume of logging residues generated annually in Northern Rocky Mountains, selected forest types*

Residue component	Forest type (acreage) LPP (30,422)	DF dry (14,163)	DF moist (37,711)	WL (20,260)	GF (17,022)	SAF (18,168)	Total[1]	
	Million cubic feet							*(MM m^3)*
Green residues								
Cull	3.6	0.7	12.6	4.5	9.6	7.1	38.1	(1.1)
Tops	13.9	1.1	3.9	2.7	3.5	5.5	30.6	(.9)
Small trees	7.4	4.2	19.9	13.4	2.7	6.9	54.5	(1.5)
Subtotal	24.9	6.0	36.4	20.6	15.8	19.3	123.2	(3.5)
Standing dead								
No defect	13.3	0	6.8	1.7				
Sound defect	8.8	1.1	1.9	.6	.4	2.8	37.4	(1.0)
Solid rot	4.2	.3	1.4	10.0				
Crumbly rot	0	0	2.1	6.1	4.4	1.2	29.7	(.8)
Subtotal	26.3	1.4	12.2	24.4	4.8	4.0	67.1	(1.8)
Down								
No defect	10.8	.6	10.0	2.2	4.8	8.3	36.7	(1.0)
Sound defect	9.4	.3	2.0	1.4	.1	.8	14.0	(.4)
Solid rot	6.5	2.5	5.2	2.5	5.2	1.9	23.8	(.7)
Crumbly rot	7.1	7.4	15.0	24.2	32.4	4.8	90.9	(2.6)
Subtotal	33.8	10.8	32.2	30.3	42.5	15.8	165.4	(4.7)
Total (nonmerchantable) MM ft^3	85.0	18.2	80.8	69.3	63.1	39.3	355.7	
(MM m^3)	(2.4)	(.5)	(2.3)	(2.0)	(1.8)	(1.1)		(10.7)

[1]Total for the forest types included in these residue studies (LPP, DF, WL, GF, SAF). In addition to the above, harvest in PP, WWP, WRC, WH, and other types results in about 110 MM ft^3 (3.1 MM m^3) of residues.

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APPENDIX

Data Sources for Residue Volume and Characteristics

Data	Source and method of computing
Area of all sawtimber (table 1)	"Forest Statistics of the U.S., 1977, Review Draft," USDA Forest Service.
Area of mature sawtimber (table 1)	Estimated from area of all sawtimber, based on proportions for National Forests, derived from forest management plans.
Volume per acre mature sawtimber stands, National Forest data (table 1)	Forest management plan data for Region 1 forests, and estimated from "Forest Statistics" area and volume data for Wyoming and southern Idaho.
Volume per acre by components and residue characteristics (tables 1 and 2)	Residue studies data, based on approximately 2,600 sample points as follows: 1. Residue study samples at forest inventory locations throughout the following National Forests: Bitterroot (Mont), Targhee (Idaho), Lolo (Mont.), Flathead (Mont.), Kootenai (Mont.). 2. Residue utilization research study sites (one or more cutting units): Coram Experimental Forest (Mont.); Lubrecht Forest (Mont.); Kaniksu NF (Idaho); Nezperce - Horse Creek (Idaho); Idaho State & NF logging study (Idaho); Wasatch NF logging study (Utah); Bridger - Teton logging study (Wyo); Bitterroot logging study (Mont.).
Residue generated annually (table 6)	1. Total volume harvested from "Production, Prices, and Employment and Trade in the Northwest Forest Industries" (PNW Station), using 1976 as base year. 2. Volume proportioned to forest type from various log receipt and harvest reports. 3. Acres in each type derived by dividing species volume above by average volume per acre for type. 4. Residue volumes per acre from table 2 applied to area by type.

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Benson, Robert E., and Joyce A. Schlieter.
1980. Logging residues in principal forest types of the Northern Rocky Mountains. USDA For. Serv. Res. Pap. INT-260, 14 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

An estimated 466 million ft^3 of forest residue material (nonmerchantable, 3 inches diameter and larger) is generated annually in the Northern Rocky Mountains (Montana, Idaho, Wyoming). Extensive studies of residues in the major forest types show a considerable portion is suited for various products. The lodgepole pine type has the greatest potential for increased residue utilization. In most other forest types, form and condition of residues limit potential use to fiber or fuel. In all forest types, volume, condition, and product potential vary widely from stand to stand.

KEYWORDS: forest residues, forest volumes, utilization

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